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(54) Transponder useful in a system for identifying objects.

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Description

This invention relates to systems for identifying objects on a remote basis. More particularly, this invention relates to transponders in such systems for providing for an identification of goods through a greater distance and with more accuracy and reliability than in the prior art.

As commerce becomes increasingly complex, increased amounts of goods have had to be handled. The difficulties of identifying individual items of goods have accordingly become aggravated. For example, merchant ships now carry large numbers of containers holding different types of products. When the merchant ship reaches a particular destination, individual ones of such containers have to be unloaded at such destination port. Systems are now in use for identifying and segregating such individual containers without requiring a personal inspection of the containers. Such identification has been made by systems which provide such identifications at positions displaced from the containers.

Many people have attempted to design useful reader-transponder systems. For example, UK patent application GB 2 163 324 A describes a transponder for vehicle identification which includes a coil antenna, a rectifier circuit, storage capacitors and a binary decoding system which drives an FET and a resonant transmitter circuit. US Patent No. 4 546 241 describes a portable card and reader where the card includes an antenna, a rectifier circuit, energy storage system and a binary coding system which controls a transistor to shunt current cyclically to drive an LC circuit including the primary receiving antenna coil. European Patent Application A2 0 111 753 describes a transponder for vehicles and other objects which receives energy through an antenna coil and shunts a voltage to ground in response to a binary control signal.

US-Patent 4075 632 describes a further transponder which is preferably used for biomedical monitoring of animals. The circuit therein shunts the received antenna voltage to ground in response to information provided by a temperature sensitive oscillator or a cyclic code generator.

Each of these circuits and other prior art circuits suffer from deficiencies, in particular a relatively limited signal to noise ratio.

The known systems, e.g. as known from US-Patent 4 075 632, employ a reader which transmits interrogating signals to a transponder associated with an individual one of the objects such as an individual one of the containers on the merchant ship. The transponder then transmits pluralities of signals to the displaced reader. The pluralities of signals are in a sequence of binary 1's and binary signals in a code individual to the object. The reader decodes the successive pluralities of signals in the sequence to identify the object. These systems now in use have certain difficulties. One difficulty results from the limited range of transmission of the identifying signals from the transponder to the reader. Another related difficulty results from the interference produced by noise signals. These noise signals have often prevented the reader from properly detecting the pattern of binary 1's and binary 0's in the sequence individually identifying the object.

The invention as described here provides a transponder which eliminates or at least minimizes the difficulties discussed above. The transponder of this invention provides an enhanced signal-to-noise ratio in comparison to the transponders of the prior art. As a result, the range of the effective distance of the transponder is considerably expanded relative to the transponders of the prior art.

In one embodiment of the invention, a reader transmits interrogating rf signals to a transponder including an antenna having a particular impedance. The signals received by the antenna are converted to a direct voltage which is introduced to a first terminal of a switch such as an emitter of a semiconductor device having conductive and non-conductive states of operation.

A second terminal of the switch, such as the base of the semiconductor device, receives a voltage variable between first and second magnitudes in accordance with a pattern of binary 1's and 0's in a data source such as a read-only memory (ROM). This pattern of binary 1's and 0's is individual to an object identified by the transponder. The variable voltage on the base of the semiconductor device causes the emitter-collector current of the semiconductor device to vary between first and second amplitudes. When this current has the first amplitude, the impedance of the semi-conductor device and the ROM substantially matches the antenna impedance. When this current has the second amplitude, the impedance of the semiconductor device and the ROM is substantially greater than the antenna impedance.

A capacitance may be connected to the collector of the semiconductor device and the ROM to store energy in accordance with the current flow through the semiconductor device. This stored energy provides for an energizing of the semiconductor device and the ROM. A diode may be connected between the emitter and the collector of the semiconductor device to pass a limited amplitude of current around the semiconductor device.

Figure 1 is a somewhat schematic diagram illustrating a system including a reader and a transponder for identifying at the reader an individual pattern of binary 1's and binary 0's identifying a displaced transponder, e.g. as known from

US-Patent 4 075 632;

Figure 2 is a somewhat schematic block diagram of an improved transponder constituting one embodiment of this invention; and

Figure 3 is a curve somewhat schematically illustrating certain of the advantages of the transponder of this invention relative to the prior art in providing enhanced signal-to-noise ratios in the signals produced in the transponder and transmitted to the reader to identify the transponder.

In Figure 1 a reader generally indicated at 10 generates interrogating rf signals in a generator 12. These signals may have a suitable frequency such as approximately nine hundred and fifteen megahertz (915 MHz). These signals are introduced to an antenna 14 for transmission to an antenna 15 in a transponder generally indicated at 16. The antenna 15 may be a dipole antenna. The transponder 16 then produces pluralities of signal cycles in an individual pattern of binary 1's and binary 0's identifying an object with which the transponder is associated. The individual pattern of binary 1's and binary 0's may be generated in a suitable data source such as a read-only memory 18. This individual pattern of binary 1's and binary 0's generated in the read-only memory 18 causes pluralities of signal cycles to be produced in a modulator 22. This general concept is prior art, see for example, US-A-4 075 632.

The modulator 22 produces a first plurality of signal cycles for a binary "1" and a second plurality of signal cycles for a binary "0".

For example a binary "0" could be produced in the modulator 20 by providing a first signal cycle at a relatively low frequency such as 20 kHz and then providing two additional signal cycles at a relatively high frequency, preferably a harmonic of the first frequency. This second frequency may be 40 kHz when the first frequency is 20 kHz. In a similar manner, a binary "1" may be produced in the modulator by signal cycles at relatively high frequency such as 40 kHz and then a single signal cycle at the relatively low frequency of 20 kHz.

The signal cycles produced in the modulator 22 are introduced to the antenna 15 for transmission to the reader 10. The reader 10 receives these signal cycles and mixes these signals in a mixer 24 with the signals from the source 12 of signals at the interrogating rf frequency. The mixed signals are amplified as at 26 and are demodulated as at 28 in accordance with the patterns of frequencies in each of the pluralities of signal cycles to obtain a recovery of the individual pattern of binary 1's and binary 0's generated at the transponder 16.

A simplified embodiment of a transponder constituting this invention is shown in Figure 2. The transponder, generally indicated at 29, includes a dipole antenna 30 constructed to receive signals from the reader at a suitable frequency such as nine hundred and fifteen megahertz (915 MHz). An impedance matching section 31 is connected to the dipole 30 to match the impedance of the dipole to the impedance of the remaining circuitry shown in Figure 2. The construction of the impedance matching section 31 is well known in the art.

The signals from the dipole 30 are introduced to a voltage-doubling rectifier generally indicated at 32. The voltage-doubling rectifier includes a pair of diodes 34 and 36 and a pair of capacitances 38 and 40 each having a suitable value such as 100 picofarads. The cathode of the diode 34 is connected to one leg of the dipole 30. The anode of the diode 34 is connected to one terminal of the capacitance 38, the other terminal of which has a common connection with the other leg of the dipole 30. The anode of the diode 36 is common with the cathode of the diode 34 and the cathode of the diode 36 has a common connection with one terminal of the capacitance 40. The other terminal of the capacitance 40 is connected to the other terminal of the dipole 30.

The anode of the diode 36 is connected to one terminal of a suitable switch. This terminal may constitute the emitter of a pnp-type of semiconductor device such as a transistor 42. The semiconductor device 42 may constitute a 2N3906. A pair of resistors 44 and 46 are in series between the base of the transistor 42 and the anode of the diode 34. The resistors 44 and 46 may respectively have values of 47 kilo-ohms and 100 kilo-ohms.

A capacitance 50 having a suitable value such as 0.01 microfarads is connected between a data source such as a read-only memory 52 and the terminal common to the resistances 44 and 46. The read-only memory 52 may be constructed in a manner conventional in the prior art. Another terminal of the read-only memory has a common connection with the collector of the transistor 42. A capacitance 54 having a suitable value such as 0.2 microfarads is in parallel with the read-only memory 52. An anode of a diode 56 may be common at one end with the collector of the semiconductor device 42 and at the opposite end with the emitter of the semiconductor device. The diode may be a type 1N914.

When signals are received by the dipole 30 from the reader 10, the signals are introduced to the rectifier 32. The positive portions of the received signals cause current to flow through a circuit including the diode 36 and the capacitance 40. The negative portions of the signals cause current to flow through a circuit including the capacitance 38 and the diode 34. As a result, rectified voltages are produced in the capacitances 40 and 38. These rectified voltages are in an additive se-

ries relationship so that the rectifier 32 acts to produce a voltage which is approximately double the amplitude of the signals received by the dipole antenna 30.

The positive voltage on the cathode of the diode 36 is introduced to the emitter of the semiconductor device 42 to bias the semiconductor device to a state of conductivity. The semiconductor device 42 accordingly becomes conductive when the voltage on the base of the semiconductor device becomes negative relative to the voltage on the emitter of the semiconductor device. The voltage on the base of the semiconductor device 42 is controlled by the operation of the data source such as the read-only memory 52.

The read-only memory 52 produces pluralities of signal cycle, each plurality indicating in coded form the value of a different binary bit. For example, a binary "0" may be represented by a single signal cycle at a first frequency such as twenty kilohertz (20 kHz) and two subsequent signal cycles at a second frequency constituting a harmonic of the first frequency. Preferably, the second frequency is forty kilohertz (40 KHz) when the first frequency is twenty kilohertz (20 kHz). Similarly, a binary "1" may be represented by two signal cycles at the second frequency (e.g. 40 kHz) and then a single signal cycle at the first frequency (e.g. 20 kHz). The read-only memory 52 is programmed to provide a sequence of binary 1's and binary 0's in a code individual to an object with which the transponder 29 is associated.

The read-only memory 52 produces signals at first and second amplitudes in accordance with the frequencies of the pluralities of signal cycles coding for the successive binary bits in the code generated by the read-only memory. When the signals from the read-only memory 52 have a low amplitude, the semiconductor device 42 becomes fully conductive so that a relatively large current flows through a circuit including the dipole 30, the impedance matching section 31, the diode 36, the emitter and collector of the semiconductor device 42, the capacitance 54 and the capacitance 38. This current is sufficiently large to produce a relatively low voltage drop across the semiconductor 42. For example, this voltage drop may be in the order of 0.1 volts.

When the voltage introduced to the base of the semiconductor device 42 from the read-only memory 52 is relatively high, the semiconductor device 42 is driven toward a state of non-conductivity. However, the semiconductor 42 device remains slightly conductive to provide a "leak-through" current through the semiconductor device. This causes a relatively high impedance to be produced across the semi-conductor device 42. The "leak-through" current through the semiconductor device 42 contributes to the production of a supply voltage across the capacitance 54.

When the semiconductor device 42 is in the fully conductive state, its impedance is relatively low. This causes the circuit including the semiconductor device 42 and the read-only memory 52 to provide an impedance approaching that provided by the dipole antenna 30 and the impedance matching section 31. This facilitates the production of currents of relatively high amplitude through this circuit. However, when the semiconductor device 42 is only slightly conductive, its impedance is large. As will be appreciated, the resultant impedance of the semiconductor device 42 and the read-only memory 52 is considerably greater than that provided by the dipole antenna 30 and the impedance matching section 31.

Figure 3 illustrates the relationship between the "back scatter" signal and the frequency of the signals being generated by the system shown in Figure 2. The "back scatter" signals are equivalent to the amplitudes of the signals introduced to the dipole antenna 30. In Figure 3, a post 60 illustrates the amplitude of the signals introduced to the antenna when the semiconductor 42 is highly conductive. The amplitude of the signals introduced to the dipole is illustrated in Figure 3 at 62 when the semiconductor 42 is only slightly conductive. As will be seen, there is a considerable difference between the amplitudes 60 and 62. This is in contrast to the operation of the circuitry of the prior art since the circuitry of the prior art provides a short circuit in a first state of operation and provides the amplitude 60 in a second state of operation. The amplitude of the signal with the circuitry of the prior art in a short circuit condition is illustrated at 64. As will be seen, there is a relatively small difference between the amplitudes 60 and 64, particularly in comparison to the difference in the amplitudes 60 and 62.

Because of the considerable difference between the amplitudes 60 and 62, the strength of the signals transmitted by the dipole 30 to the reader 10 is considerably enhanced in relation to any noise received by the reader. As a result, the reader 10 is able to detect the signals from the transponder 29 through a greater distance than in the prior art. The reader 10 is also able to detect the signals from the transponder 29 with a greater reliability than in the prior art. This causes the reader 10 to identify the transponder 29 and its associated object through an increased distance and an enhanced reliability relative to the capabilities of the transponders of the prior art.

The ability of the reader 10 to detect the object is also enhanced because of other advantages provided by the transponder shown in Figure 2. For example, approximately one tenth volt (0.1V) is

produced across the semiconductor device 42 when the semiconductor device is highly conductive. This is in contrast to the prior art which produces voltage drops as high as three tenths of a volt (0. 3V). This difference is quite considerable in comparison to the voltage produced across the capacitance 54. This voltage may be in the order of one and eight tenths volts (1.8V). As a result, the voltage used to generate the transponder signals in the transponder shown in Figure 2 and described above is significantly greater than the voltage used to generate such signal in the prior art.

The capacitance 54 has considerably higher values than the capacitances 38 and 40. The capacitance 54 accordingly serves as the primary source of energy for the read-only memory 52 and the semiconductor device 42. The capacitances 38 and 40 provide energy for the emitter-base current in the semiconductor device 42. The capacitance 50 serves as a coupling capacitance between the read-only memory 52 and the base of the semiconductor device 42. The resistance 44 limits the current between the emitter and the base of the semiconductor device 42. The resistance 46 provides an impedance between the coupling capacitance 50 and a reference potential such as ground.

Claims

1. A transponder (29) to be associated with an object, the transponder being designed for responding to signals from a transmitter/reader (10) to identify the object the transponder including:

   antenna means (30,31) to receive interrogating signals from the transmitter/reader (10), the antenna means (30,31) having a particular antenna impedance,

   a data source (52) to provide a sequence of binary indications individually identifying the object,

   switching means (42,44,46,50) having first and second states of operation and having a low impedance in the first state of operation and a high impedance in the second state of operation, the switching means including a semi conductor (42) for varying the antenna impedance, the semiconductor (42) having a first, a second and a third electrode,

   energy storing means (54) to receive energy from the electromagnetic field provided by the transmitter/reader (10),

   the first and third electrodes of the semiconductor being connected in series between the antenna means (30,31) and the energy storing means (54), and said data source (52) being connected in parallel to said energy storing means,

   load means including the data source (52) and the switching means (42) for defining a load having an impedance in the first state of operation corresponding to the impedance of the antenna means (30,31) and having an impedance in the second state of operation considerably higher than the impedance of the antenna means (30,31),

   binary response means (52) connected to selectively operate on the second electrode of the semiconductor (42) of the switching means in the first and the second state of operation in response to and in accordance with the sequence of binary indications in the data source (52) to introduce the sequence of binary indications to the second electrode of the semiconductor to obtain the operation of the switching means in the first and second states of operation in accordance with the sequence of binary indications individually identifying the object,

   rectifier means (32) connected between the antenna means (30) and the switching means to load the energy storing means (54),

   CHARACTERIZED IN THAT

   the rectifier means (32) includes a voltage doubling rectifier with two diodes (34,36) connected in series from anode to cathode and two capacitors (38,40) connected in series, the two diodes connected in parallel to the two capacitors,
   the first electrode of the semiconductor (42) is connected to a point between one (36) of the diodes (34,36) and its adjacent capacitor (40), the point between the other diode (34) and its adjacent capacitor (38) is connected to ground and the antenna means (30,31) is connected to a point between the two diodes (34,36) and to a point between the two capacitors (38,40).

2. Transponder according to Claim 1,

   CHARACTERIZED IN THAT

   current limiting means (56) are connected across the first and third electrode of the semiconductor (42) of the switching means to pass a limited flow of current around the semicon-

ductor (42) of the switching means in the second state of operation of the switching means.

3. Transponder according to claim 1 or 2.

CHARACTERIZED IN THAT

said data source (52) being a read-only memory.

4. Transponder according to at least one of the preceding claims

CHARACTERIZED IN THAT

the antenna means includes a dipol antenna (30) and an impedance matching section (31).

Revendications

1. Répondeur (29) pouvant être associé à un projet, le répondeur étant concu de façon à répondre à des signaux provenant d'un transmetteur/lecteur (10) pour identifier l'objet du répondeur comprenant :

des moyens d'antenne (30, 31) pour recevoir des signaux d'interrogation provenant du transmetteur/lecteur (10), les moyens d'antenne (30, 31) ayant une impédance d'antenne particulière,

une source de données (52) pour fournir une séquence d'indications binaires identifiant individuellement l'objet,

des moyens de commutation (42, 44, 46, 50) ayant des premier et second états de fonctionnement et ayant une faible impédance dans le premier état de fonctionnement et une haute impédance dans le second état de fonctionnement, les moyens de commutation comprenant un semi-conducteur (42) pour varier l'impédance d'antenne, le semi-conducteur (42) ayant une première, une deuxième et une troisième électrode;

des moyens de stockage de l'énergie (54) pour recevoir l'énergie à partir du champ électromagnétique fourni par le transmetteur/lecteur (10),

la première et la troisième électrodes du semi-conducteur étant connectées en série entre les moyens d'antenne (30, 31) et les moyens de stockage de l'énergie (54), et ladite source de données (52) étant connectée en parallèle auxdits moyens de stockage de l'énergie,

des moyens de chargement comprenant la source de données (52) et les moyens de commutation (42) pour définir une charge ayant une impédance dans le premier état de fonctionnement correspondant à l'impédance des moyens d'antenne (30, 31) et ayant une impédance dans le second état de fonctionnement considérablement supérieure à l'impédance des moyens d'antenne (30, 31),

des moyens de réponse binaire (52) connectés de façon à fonctionner de manière sélective sur la deuxième électrode du semiconducteur (42) des moyens de commutation dans le premier et dans le second état de fonctionnement en réponse et conformément à la séquence des indications binaires dans la source de données (52) pour introduire la séquence des indications binaires dans la deuxième électrode du semi-conducteur pour obtenir le fonctionnement des moyens de commutation dans les premier et second états de fonctionnement conformément à la séquence des indications binaires identifiant individuellement l'objet,

des moyens de redressement (32) connectés entre les moyens d'antenne (30) et les moyens de commutation pour charger les moyens de stockage de l'énergie (54),

CARACTERISE EN CE QUE

les moyens de redressement (32) comprennent un redresseur-doubleur de tension avec deux diodes (34, 36) connectés en série de l'anode à la cathode et deux condensateurs (38, 40) connectés en série, les deux diodes connectées en parallèle aux deux condensateurs,

la première électrode du semi-conducteur (42) est connectée à un point entre l'une (36) des diodes (34, 36) et son condensateur adjacent (40), le point entre l'autre diode (34) et son condensateur adjacent (38) est mis à la masse et les moyens d'antenne (30, 31) sont connectés à un point entre les deux diodes (34, 36) et à un point entre les deux condensateurs (38, 40).

2. Répondeur selon la Revendication 1,

CARACTERISE EN CE QUE

les moyens limiteurs de courant (56) sont connectés à travers la première et la deuxième électrodes du semiconducteur (42) des moyens de commutation pour faire passer un flux limité de courant autour du semiconducteur (42) des moyens de commutation dans le second état de fonctionnement des moyens de commutation.

3. Répondeur selon la revendication 1 ou 2.

CARACTERISE EN CE QUE

ladite source de données (52) est une mémoire morte.

4. Répondeur selon au moins une des revendications précédentes
CARACTERISE EN CE QUE
les moyens d'antenne comprennent une antenne de dipôle (30) et une section d'adaptation des impédances (31).

Patentansprüche

1. Transponder (29) zum Gebrauch an einem Objekt, welcher zum Antworten auf Signale von einem Ubertrager/Leser (10) ausgelegt ist, um damit das Objekt zu identifizieren, mit:

einer Antenneneinrichtung (30, 31) zum Empfangen eines Anforderungssignals von dem Ubertrager/Leser (10), wobei die Antenneneinrichtung (30, 31) eine bestimmte Antennenimpedanz aufweist,

einer Datenquelle (52) zum Bereitstellen einer Abfolge von binären Signalen, welche das Objekt individuell kennzeichnen,

einer Umschalteinrichtung (42, 44, 46, 50) mit einem ersten und zweiten Betriebszustand, wobei sie in dem ersten Betriebszustand eine geringe Impedanz und in dem zweiten Betriebszustand eine hohe Impedanz aufweist, wobei die Umschalteinrichtung einen Halbleiter zum Variieren der Antennenimpedanz enthält, der eine erste, zweite und dritte Elektrode aufweist,

einer Energiespeichereinrichtung (54) zum Empfangen von Energie aus dem elektromagnetischen Feld, welches von dem Ubertrager/Leser (10) abgegeben wird, wobei die erste und dritte Elektrode des Halbleiters in Serie zwischen der Antenneneinrichtung (30, 31) und der Energiespeichereinrichtung (54) verschaltet ist und die Datenquelle (52) parallel mit der Energiespeichereinrichtung verbunden ist,

einer Lasteinrichtung, die die Datenquelle (52) und die Umschalteinrichtung (42) umfaßt zum Definieren einer Last, die im ersten Bet riebszustand eine Impedanz entsprechend der Impedanz der Antenneneinrichtung (30, 31) hat und in dem zweiten Betriebszustand eine Impedanz aufweist, die beträchtlich höher ist als die Impedanz der Antenneneinrichtung (30, 31),

einer binären Antworteinrichtung (52), die so verbunden ist, daß sie selektiv über die zweite Elektrode des Halbleiters (42) die Umschalteinrichtung in dem ersten und dem zweiten Betriebszustand betreiben kann in Antwort auf und in Ubereinstimmung mit einer Folge von binären Signalen in der Datenquelle (52) um die Folge der binären Signale der zweiten Elektrode des Halbleiters zuzuführen, um den Betrieb der Schalteinrichtung in dem ersten und zweiten Betriebszustand entsprechend der Folge der binären Signale, die das Objekt individuell kennzeichnen, zu erhalten,

einer Gleichrichtereinrichtung (32), die zwischen der Antenneneinrichtung (30) und der Schalteinrichtung verbunden ist, um die Energiespeichereinrichtung (54) aufzuladen,

dadurch gekennzeichnet,

die Gleichrichtereinrichtung (32) einen Doppelgleichrichter mit zwei Dioden (34, 36), die in Serie mit der Anode zur Kathode verbunden sind, und zwei seriell verschaltete Kapazitäten (38, 40), wobei die zwei Dioden parallel zu den zwei Kapazitäten verschaltet sind, die erste Elektrode des Halbleiters (42) mit einem Punkt zwischen einer (36) der Dioden (34,36) und ihrer benachbarten Kapazität (40) verbunden ist, der Punkt zwischen der anderen Diode (34) und ihrer benachbarten Kapazität (38) mit Erde verbunden ist und die Antenneneinrichtung (30,31) mit einem Punkt zwischen den zwei Dioden (34, 36), und mit einem Punkt zwischen den zwei Kapazitäten (38,40) verbunden ist.

2. Transponder nach Anspruch 1, **dadurch gekennzeichnet,** daß eine Strombegrenzungseinrichtung (56) zwischen der ersten und dritten Elektrode des Halbleiters (42) der Umschalteinrichtung verbunden ist, um einen begrenzten Stromfluß um den Halbleiter (42) der Umschalteinrichtung während des zweiten Betriebszustands der Umschalteinrichtung vorbeizuleiten.

3. Transponder nach Anspruch 1 oder 2, **dadurch gekennzeichnet,** daß die Datenquelle (52) ein ROM ist.

4. Transponder nach mindestens einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet,** daß die Antenneneinrichtung eine Dipolantenne (30) und eine Impedanzanpaßstufe (31) aufweist.

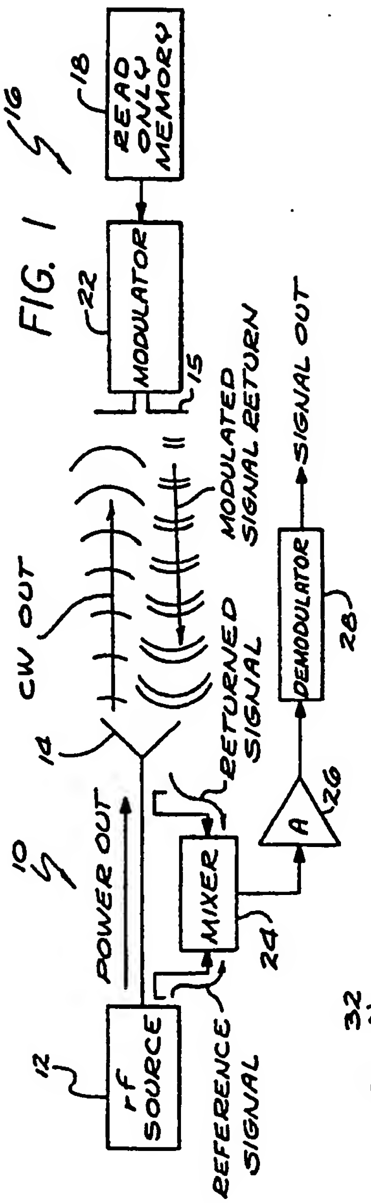

FIG. 1

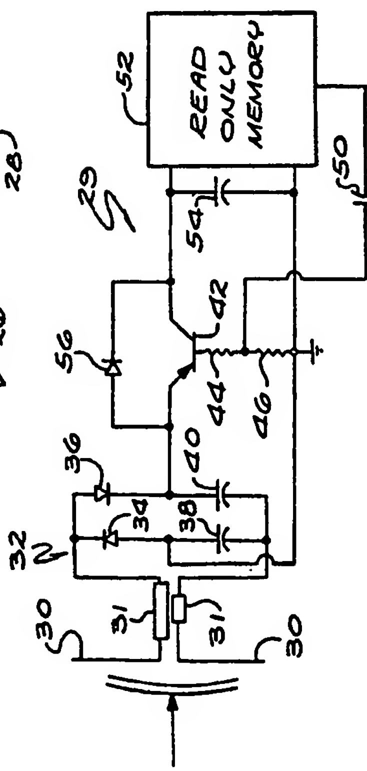

FIG. 2

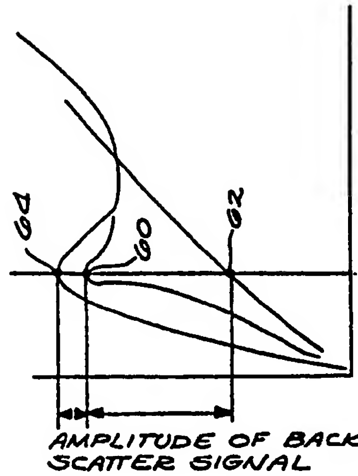

FIG. 3